REMARKS

The present invention relates to a radiographic imager having a radiated signal measuring device for determining the distance between an x-ray source and an image receptor associated with the radiographic imager. In one embodiment, a radiated signal source is positioned at one of the x-ray source or image receptor associated with the radiographic imager and is operative to project a radiated signal. A detector is positioned at the other one of the x-ray source or image receptor and is operative to detect the radiated signal. By measuring the travel time of the radiated signal, the source-to-receptor distance is computed .

The Examiner rejected all pending claims under 35 U.S.C. § 103 as being unpatentable over U.S. Patent No. 5,485,502 to Hinton *et al.* ("Hinton") in combination with U.S. Patent No. 6,167,292 to Badano *et al.* ("Badano"). Hinton discloses computer control of a radiographic instrument to prevent collisions when repositioning the x-ray source and image receptor with respect to a patient. col. 1, lines 5-10. That is, Hinton discloses a <u>collision avoidance system</u>. col. 2, lines 40-44. Nowhere does Hinton disclose or suggest using a radiated signal system to measure the distance from the x-ray source of the radiographic instrument to its image receptor. In the disclosure of Hinton, both points are <u>fixed</u> relative to each other, and their relative distance <u>never changes</u>. Referring to Figure 1, "A radiation source 44, which is an x-ray tube, is <u>mounted at one end of the C-arm 40</u> and is oriented to direct a polychromatic z-ray fan beam 48 [towards a patient table] . . ." col. 4, lines 44-46. "The fan beam 48 is received by a bi-linear detector array 50 <u>mounted on the other end of the C-arm 40</u> . . ." col. 4, lines 53-54. The x-ray source and image receptor are thus both mounted on opposite ends of a <u>fixed</u> C-shaped arm. To properly position a patient with respect to the x-ray source and image receptor, the patient may be raised and lowered, and the C-arm may be moved longitudinally and transversely, and rotated about a center point:

> Referring now to FIGS. 1 and 2, the radiographic system 10 provides relative motion between the x-ray source 44 and the x-ray detector 50 and the patient 14 in four dimensions: one corresponding to each of the three

> Cartesian coordinates of x, y and z and one corresponding to the angle θ. Specifically, table 12 may be moved up and down in the y-axis. The C-arm may be moved transversely in the x-axis and longitudinally in the z-axis, and the C-arm 40 may be rotated in the θ axis.

col. 5, lines 33-41.

Nowhere does Hinton disclose or suggest that the x-ray source 44 and the x-ray detector 50 are moved relative to each other, or that their relative spatial position – including the distance between them – ever changes. To the contrary, Hinton discloses that they are fixedly mounted to opposite ends of a rigid C-arm, which is not disclosed as having any telescoping or deforming capability. Hence, there is no need in Hinton to measure the distance from x-ray source to the image receptor, and indeed such measurement would be totally superfluous. In stark contrast, claim 1 explicitly recites a circuit connected to the to radiated image source and detector, "said circuit operative to determine the travel time of said radiated signal between said x-ray source and said image receptor, and <u>thereby determine the distance between the x-ray source and the image receptor</u>." Claims 8, 10 and 17 recite similar limitations. Hinton neither discloses nor suggests any means for measuring the distance between an x-ray source and image receptor.

Furthermore, the only radiated signal sources disclosed by Hinton that are used to determine distance are "one or more ultrasonic transducers 57 [that] may be incorporated into various portions of the radiation source 44, arm 40 and detector array 50 <u>so as to detect a close proximity between these surfaces and another surface</u> during control of the radiographic system 10." col. 12, lines 54-57. This disclosure is inapposite to the present invention for several reasons. First, the ultrasonic transducers 57 are not disclosed as being positioned on one and the other of an x-ray source and image receptor, as recited in claims 1 and 8, and measuring the distance between these points, as recited in claims 1, 8, 10 and 17. Rather, the transducers are incorporated on the radiation source 44 (x-ray source), <u>and</u> the detector array 50 (image receptor), and are operative detect proximity (measure distance) between these points and <u>another surface</u>.

Additionally, Hinton does not disclose generating a radiated signal source in one location and detecting it in another, as recited in claims 1 and 8. Hinton does not disclose the details of ultrasonic transducers 57, but from the context and function described for them, one of skill in the art must assume the ultrasonic transducers 57 are self-contained units that measure the distance from an arbitrary surface – that is, that both the ultrasonic signal source and detector are co-located at the "transducer 57," and it is round-trip timing to a proximate surface and back that is used to calculate the distance. Both claims 1 and 8 explicitly recite a separate radiated signal source and detector, and furthermore positively place them at different locations.

The failure of Hinton to teach or suggest a radiated signals system to measure the distance from an x-ray source to an image receptor is not cured by combination with Bandano. As discussed extensively in a prior response, Badano discloses a method and apparatus for registering patient space with image space for robotic surgery. In robotic surgery, preoperative images are initially taken of the area to be operated on. Bandano discloses no teaching or suggestion that a radiated signal measurement system is used to determine the x-ray source to image receptor distance during this imaging. Subsequent to studying the images and deciding on a surgical path, a robotic system is programmed to follow the surgical path. To do so, the robot must first orient itself to the patient – that is, the robot's frame of reference (referred to as patient space) must be registered with the frame of reference of the preoperative image (image space). Bandano discloses that this may be accomplished by affixing an insert to the patient (such as into his skull), the insert holding a first support element having markers that are visible in the preoperative, diagnostic images. During surgery, a second support element is substituted for the first, having ultrasonic transducers affixed in lieu of the markers. The robot then aligns the ultrasonic transducers (patient space) with the markers in the preoperative images (image space) to orient itself such that the path planned through image space corresponds to the proper path in patient space.

Absolutely nothing in Bandano is remotely related to using a radiated signal source and detector to determine the distance between an x-ray source and an image receptor for a radiographic imaging system. In Bandano, the radiographic imaging and the use of ultrasonic transducers is explicitly separated into separate and distinct phases – preoperative imaging and surgery – wherein the ultrasonic transducers are not used at all in the radiographic imaging phase. Their only disclosed utility is to align the robot's patient space during surgery to the image space used to route the surgical path.

The combination of Hinton and Bandano cannot and does not render obvious that which neither reference remotely suggests. Independent claims 1, 8, 10 and 17 explicitly recite determining the distance between an x-ray source and an image receptor in a radiographic imaging system. Hinton does not teach or suggest any measurement system – much less a radiated signal measurement system – to determine the distance between an x-ray source and associated image receptor. This would be a completely useless capability, as the x-ray source and image receptor of Hinton are mounted on oppose ends of a fixed C-arm, and their relative distance never changes. Bandano does not even disclose a radiographic system, other than to mention in passing that one must previously have been utilized to take preoperative diagnostic images with identifiable markers in them. Ultrasonic transducers are then utilized to align the image space to the patient space in which a surgical robot operates. As the references, either alone or in combination, fail to teach or suggest the limitations of the claims, the rejections under 35 U.S.C. § 103 are improper and must be reversed. Additionally, as every dependent claim includes all limitations of its parent claims, the dependent claims also exhibit patentable nonobviousness over Hinton and Bandano.

All pending claims defining patentably over the prior art, prompt allowance of the present application is respectfully requested.

Respectfully submitted,

COATS & BENNETT, P.L.L.C.

Dated: May 17, 2004

Edward H. Green, III
Attorney for Applicants
Registration No.: 42,604

P.O. Box 5
Raleigh, NC 27602
Telephone: (919) 854-1844